इंटरनेट मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

"जानने का अधिकार, जीने का अधिकार"
Mazdoor Kisan Shakti Sangathan
"The Right to Information, The Right to Live"

"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS 988 (1959): General requirements for optical components
[PGD 22: Educational Instruments and Equipment]

"ज्ञान से एक नये भारत का निर्माण"
Satyanarayan Gangaram Pitroda
"Invent a New India Using Knowledge"

Act Number 22 of 2005
The Indian Parliament
RIGHT TO INFORMATION

Made Available By
Public.Resource.Org

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

BLANK PAGE

BRUTUM FULMEN
IGNORANTIA JURIS NON EXCUSAT
PROTECTED BY COPYRIGHT

IS : 988 - 1959
(Reaffirmed 2006)

Indian Standard

GENERAL REQUIREMENTS FOR OPTICAL COMPONENTS

(Fourth Reprint AUGUST 1993)

UDC 681·4

© *Copyright* 1959

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 5 *September* 1959

Indian Standard

GENERAL REQUIREMENTS FOR OPTICAL COMPONENTS

Optical and Mathematical Instruments Sectional Committee, EDC 36

Chairman	
Dr C. S. Rao	Directorate of Technical Development (Ministry of Defence)
Members	
Assistant Director Standardization (Civil)	Research, Design & Standardization Organization (Ministry of Railways)
Shri K. L. Bajaj	Directorate General of Ordnance Factories, Calcutta
Shri Balvir Singh	Grah Udyog Sahakari Samiti Ltd, Roorkee
Shri I. S. Ghulati	Office of the Development Commissioner (Small Scale Industries) (Ministry of Commerce & Industry)
Shri K. N. S. Iyengar	Engineer-in-Chief's Branch, Army Headquarters (Ministry of Defence)
Col R. S. Kalha	Survey of India, Dehra Dun
Lt-Col S. K. S. Mudaliar (*Alternate*)	
Shri N. M. Malkani	Central Public Works Department (Ministry of Works, Housing & Supply)
Shri Prem Prakash	National Physical Laboratory (CSIR), New Delhi
Shri P. Hariharan (*Alternate*)	
Shri S. Raghavachari	Central Water & Power Commission, New Delhi
Shri D. P. Jethwani (*Alternate*)	
Shri E. B. Rajderkar	Sarvashri Raj-Der-Kar & Co, Bombay
Shri K. Rajagopalan (*Alternate*)	
Commander S. Rajendra	Indian Navy
Dr I. Ramakrishna Rao	Madras Institute of Technology, Madras
Shri A. N. Sen	National Instruments (Private) Ltd, Calcutta
Shri R. R. Chakravarty (*Alternate*)	
Prof S. R. Singh	Roorkee University, Roorkee
Shri P. V. Subba Rao	Andhra Scientific Co Ltd, Masulipatam
Shri M. M. Vadi	Development Wing (Ministry of Commerce & Industry)
Shri S. P. Verma (*Alternate*)	
Shri K. Srinivasa Rao (*Alternate*)	
Shri H. C. Verma	Associated Instruments Manufacturers (India) Ltd, New Delhi
Dr Lal C. Verman (*Ex-Officio*)	Director, ISI
Secretary	
Shri M. V. Patankar	Assistant Director (Engg), ISI

(*Continued on page* 2)

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

(*Continued from page* 1)

Optical Instruments Subcommittee, EDC 36 : 2

Convener	
Shri A. N. Bhattacharyya	Directorate of Technical Development (Ministry of Defence)
Members	
Shri S. S. Dharmayya (*Alternate* to Shri A. N. Bhattacharyya)	
Shri P. Hariharan	National Physical Laboratory (CSIR), New Delhi
Shri Prem Prakash (*Alternate*)	
Shri S. Hariharan	Madras Institute of Technology, Madras
Shri D. C. Roy	National Instruments (Private) Ltd, Calcutta
Shri S. K. Roy	Directorate General of Ordnance Factories, Calcutta
Shri P. V. Subba Rao	The Andhra Scientific Co Ltd, Masulipatam

Indian Standard
GENERAL REQUIREMENTS FOR OPTICAL COMPONENTS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 19 February 1959, after the draft finalized by the Optical and Mathematical Instruments Sectional Committee had been approved by the Engineering Division Council.

0.2 This is one of a series of Indian Standards relating to optical instruments being prepared by the Institution. A proposal for formulation of national standards for optical instruments was first received from the National Instruments Private Ltd, Calcutta in 1955. The Ministry of Commerce & Industry set up a Committee in 1956 and one of its terms of reference was to recommend to ISI a list of instruments for which Indian Standards need to be formulated on a priority basis. The Scientific Instruments Committee of the Planning Commission, which has recently submitted its report, has also stressed the need for the Institution intensifying its work of formulating national standards for different types of instruments.

0.3 Optical components of a number of varieties are used on a large scale by the industry either as such or as parts of large systems. Their requirements as regards quality of material, workmanship and finish, precision and stringency of performance characteristics, vary according to the nature and function of the component and its exact location in the system or instrument. In view of these considerations (although it would appear to be impracticable to lay down a common standard for all types of optical components), it is still possible, firstly, to sort out the components according to the generic types, like prisms, lenses and mirrors, and to specify the more general requirements which each of these types should invariably satisfy irrespective of its function or location in a system or instrument. Further, such of the other parts of the system (of which the optical component forms a part), as are specific to the functional characteristics of the instrument or system, of which the optical component is an integral part, are not covered by the present standard but are only referred to in some cases. For these special requirements, reference should, therefore, be made to the relevant standards.

0.3.1 As the general requirements dealt with in this standard are applicable to all types of optical components, irrespective of their location or functional aspect in a system or in an instrument, this standard will be quoted as a basic standard of reference in all other specifications for optical systems or instruments as far as the common requirements, to which their components should be produced and supplied, are concerned.

0.4 The Sectional Committee responsible for the preparation of this standard gave due consideration to the views of producers, consumers and technologists and felt that it should be related to the trade and manufacturing practices prevailing not only in this country but also in other countries.

0.4.1 The details of preferred radii of curvature for glass-working tools given in Appendix B are those recommended in a paper by T. Smith entitled 'The Spacing of Glass-Working Tools' included in National Physical Laboratory (UK) Collected Researches, Vol. XVII (1922).

0.5 This standard requires reference to the following Indian Standards:

*IS : 170-1950 SPECIFICATION FOR ACETONE

*IS : 321-1952 SPECIFICATION FOR ETHYL ALCOHOL (ABSOLUTE ALCOHOL)

*IS : 1286-1958 PICTORIAL MARKINGS FOR HANDLING INSTRUCTIONS FOR NON-DANGEROUS GOODS

IS : 1399-1959 GLOSSARY OF TERMS USED IN OPTICAL TECHNOLOGY

IS : 1400-1960 SPECIFICATION FOR OPTICAL GLASS

0.5.1 Wherever a reference to any standard mentioned in **0.5** appears in this standard, it shall be taken as a reference to the latest version of the standard.

0.6 In view of the Government of India's decision to introduce a uniform system of weights and measures throughout the country, based on the metric system, all measurements appearing in this standard are given in metric units.

0.7 This standard is intended chiefly to cover the general technical provisions relating to optical components, and it does not include all the necessary provisions of a contract.

0.7.1 It should also be emphasized that whilst compliance with the general requirements would go an appreciable way in detailing general requirements covering quality, this standard will need to be supplemented by specifications covering components or assemblies in which the components might be fitted.

1. SCOPE

1.1 This standard prescribes the general technical requirements and the methods of test for the following types of finished basic optical components used in optical instruments or optical systems:

---

*Since revised.

a) Lenses
b) Prisms
c) Mirrors
d) Graticules or diaphragms
e) Plates, parallel and prismatic
f) Optical filters

1.1.1 For the special requirements governed by the individual assembly, *location or function of the component in a particular system or instrument*, reference should be made to the relevant specification for the instrument or system, as the case may be.

2. TERMINOLOGY

2.1 The general technical terms used in this standard have the same significance or definitions as given in IS : 1399-1959.

3. MATERIALS

3.1 Optical Glass — Optical glass conforming to IS : 1400-1960.

3.1.1 For optical components with surfaces exposed to the atmosphere, the more stable types of optical glass shall be used.

3.2 Optical Cement — In the case of cemented components, the optical cement used and the method of processing adopted during cementing shall be such as to ensure a perfectly adherent, continuous, thin, uniform jointing surface free from colour or bubbles or other inclusions. It shall, further, continue to remain satisfactory and free from defects when subjected to the following temperature conditions:

a) 60°C dry at one end and 0°C at the other end, and
b) 55°C with 95 percent relative humidity at one end and 0°C at the other end.

4. MANUFACTURE AND WORKMANSHIP

4.1 Surface Finish — Polished surfaces, when inspected against an illuminated ground or opal glass surface, shall show no evidence of greyness or stain. They shall also be reasonably free from other surface defects like scratches and sleeks, and digs and pits. Further, when a well defined source of light is seen by oblique reflection at the polished surface, the surface shall exhibit the highest degree of polish possible in high grade optical practice, and provide a clearly defined undistorted image of the object. The nature of the surface finish shall be further tested, where specified, by means of suitable interference methods.

NOTE — The effect of a particular defect or defects on the surface of or within an element on the performance is a function of the position of the element in the optical system. For example, surface defects in elements or in components not near a focal plane are not as important as those which lie in or near a focal plane. As a general guide, the order of importance may be roughly indicated as follows:

a) *Most critical surfaces*
  1) The marked surface of a graticule
  2) Surfaces of collective lenses in a focal plane

b) *Less critical surfaces*
  1) Surfaces of ocular field lenses nearest the graticule
  2) Collective lenses, or prism surfaces near a focal plane

c) *Least critical surfaces* — All other surfaces of windows, objectives, prisms, erectors and eye lenses

4.2 Centering, Edging and Chamfering

4.2.1 The optical components shall be suitably edged and chamfered by grinding so as to remove sharp edges and to obviate their liability to chipping subsequently.

4.2.2 In the case of lenses, cemented or otherwise, the edges shall be true to the diameter about the optical axis as a centre. Lenses consisting of two or more elements shall be cemented and centered in such a manner that the axes of all the elements are collinear. Ocular lenses shall be concentric to within 6 minutes of arc and all other lenses shall be concentric to within 3 minutes of arc unless otherwise specified. After centering and cementing, no glass overhang shall be left.

NOTE — Eccentricity of the component is the angular deviation, after refraction, of an incident ray which is coincident with the geometric axis of the lens.

4.3 Edge Chips — Edge chips, with the exception of roof edges of prisms, which do not encroach on the free aperture, may be permitted as long as they are very small in size. Further, the surfaces of all chips, larger than 0·5 mm in the maximum dimension shall be 'stoned' to roughen them and to lessen the possibility of annoying reflections and additional chipping.

4.4 Padding — In the case of components assembled or mounted in their casings or cells, any kind of padding or packing under or around optical components shall not be used unless specifically permitted. If, however, the components are required to be sealed in their housings, the sealing material shall be such as will not deteriorate under tropical atmospheric conditions or be affected by lubricants, paints and varnishes normally used in optical instruments.

4.5 Silvering

4.5.1 In the case of silvered components like mirrors, prisms and plates, the silvering on glass surface may be done either by chemical deposition of silver or by evaporation of aluminium under high vacuum and may provide either a completely reflecting surface or a semi-reflecting and semi-transmitting surface, as may be specified by the purchaser. The quality of the silvered surface may be tested for the following requirements:

a) Reflection coefficient of the silvered surface for white light may be determined by photometric measurement at 45° (±2°) angle of incidence. As an alternative or as a referee test, the value of the integrated luminous reflectance may be obtained from spectrophotometric data. This shall be not less than 88 percent.

b) Reflection/transmission ratio may be determined for semi-silvered components by photometric measurement.

4.5.2 The silvered surfaces shall be suitably protected against damage by abrasion during normal handling and against deterioration due to atmospheric conditions. The effectiveness of the protective coating on the silvered film shall be tested by subjecting it to accelerated damp heat conditions specified in **7.5**.

4.6 Blooming — Many optical components like lenses, prisms and windows are bloomed with a view to reducing the reflection losses at the air/glass interfaces of the components and thereby increasing the light transmission through the system. The durability of the anti-reflecting film deposited on the glass surface under high vacuum conditions may be tested by the method described in Appendix A.

4.7 Dimensions — Overall dimensions of the component shall conform to the figures laid down in the relevant drawing and shall be within the tolerances specified, if supplied unassembled or unmounted, so as to facilitate proper assembly in its housing. Where no tolerances are mentioned, a tolerance of ±0·1 mm on the nominal dimensions shall be allowed.

4.8 Workmanship — Workmanship shall be in accordance with the highest grade optical practice consistent with the intended use of the component in question.

4.9 To facilitate inspection and acceptance, a drawing/diagram of the optical system of which the component forms a part shall ordinarily be provided.

5. LENSES

5.1 Lenses may be supplied as single lenses or as combinations thereof, cemented or separate and mounted or unmounted in their cells or housings as specified by the purchaser. One or both surfaces of a lens may be spherical, cylindrical, aspherical or plane.

NOTE — Lenses with spherical surfaces (one or both) are the more common. As a step towards standardization, it is recommended that spherical surfaces of lenses may be designed and produced making use of tools with preferred radii of curvature given in Appendix B.

5.2 Focal Length

5.2.1 The equivalent focal length of the lens or lens combination, as determined by the Nodal Point Method, the Newton's Method or the Magnification Method (*see* Appendix C), or by using a Standard Focometer Method, shall be within ±5 percent of the nominal value, unless otherwise specified.

5.2.2 The back focal length of a positive lens or lens combination, as measured by the distance from the back surface of the lens to the image formed by the lens of a distant axial object, shall not vary by more than ±5 percent of the nominal value, unless otherwise specified.

5.3 Aperture — The relative aperture of the lens or lens combination shall be within ±5 percent of the nominal value, unless otherwise specified.

5.4 Thickness — The centre thickness of a positive lens shall be not less than one-ninth and that of a negative lens not less than one-twelfth of the diameter of the lens. Further, the edge thickness of a positive lens shall be not less than one millimetre.

5.5 Figure — The departure from spherecity or flatness of a lens surface shall be such as to give, unless otherwise specified, not more than one fringe for first grade work, two fringes for good quality and three fringes for average quality, for every 25 mm of diameter. The test shall be carried out with a test plate of near about the same size using sodium light.

5.6 Definition — In the case of lenses, or combinations of lenses, which are independently corrected or are to be independently used, the image formed by the lens of a standard test object shall be such that there is no perceptible impairment of definitions up to two-thirds of the field at which the lens is to be used.

5.7 Cylindrical Lens — In the case of a cylindrical lens:

a) The radius of curvature of the cylindrical surface shall be within ±5 percent of the nominal value, unless otherwise specified;

b) The axis of the lens shall not differ from the specified direction by more than ±1°; and

c) Its power in a plane containing the axis of the generating cylinder shall not exceed ±0·25 dioptre.

5.8 Microscope Objective — In the case of a microscope objective, the numerical aperture shall be not lower than the marked value by more than 3 percent. All microscope objectives shall be corrected for a mechanical tube length of 170 mm and for a cover glass thickness of 0·18 mm when used.

6. PRISMS

6.0 A prism is used in an optical system or instrument to deviate the incident beam to the desired convenient direction, or to invert or revert the image formed by the system, or to disperse an incident beam of heterochromatic light into its constituent wavelengths.

6.1 Depending on their functional use, prisms shall be tested for the requirements given in **6.1.1** to **6.1.7**.

6.1.1 *Prism Angle* — When measured by a goniometer or spectrometer, the prism angles shall be correct to the specified values to within ±3 minutes for 90° angles and to within ±5 minutes for other angles, unless otherwise specified.

6.1.2 *Deviation Angle* — When measured by any of the methods indicated in **6.1.1**, the deviation angle shall be correct to within ±5 minutes, unless otherwise specified.

6.1.3 *Pyramidal Error* — Pyramidal error may be measured using a goniometer fitted with a graticule having both horizontal and vertical calibrated scales. The prism under test should first be adjusted on the prism table such that the back reflected image of the horizontal line of the graticule from the two adjacent polished faces of the prism, coincides with the horizontal line on the graticule in each case. This may be achieved by manipulating the levelling screws of the prism table, but packing may become necessary in some cases. This adjustment is necessary to ensure that the edge between the two faces becomes perpendicular to the optical axis of the autocollimator telescope. Once this is done, the telescope should be directed towards the face opposite to the perpendicular edge. The displacement of the back reflected horizontal line image on the vertical scale gives the pyramidal error. The mean of the error measured with respect to each edge and its opposite face should be taken to arrive at the final value, which shall not exceed ±3 minutes, unless otherwise specified.

6.1.4 *Roof Angle* — A prism provided with a 90°-roof angle, when tested with a goniometer, shall not form a double image.

6.1.5 *Parallelism of Faces* — In the case of a rhomboid prism, the parallelism of the faces, when tested with a goniometer, shall be correct to within ±10 seconds, unless otherwise specified.

6.1.6 *Equivalent Optical Path* — The equivalent optical path may be determined by direct measurement and shall be correct to within ±5 percent, unless otherwise specified.

6.1.7 *Definition* — The definition chart or board, when viewed through the prism under test, shall appear reasonably well defined.

7. MIRRORS

7.1 Surface Defects — Finished mirrors to be assembled in or near the focal plane of instruments require special care in processing. Surfaces of such mirrors shall be visibly free from particles, pin holes or scratches. Such imperfections outside the free aperture of the mirror shall not, however, entail rejection.

7.2 Adherence Test — Adhesivity of the silvered/aluminized film to the glass surface in the case of front silvered mirrors shall be tested as follows:

> The sticky surface of a cellulose adhesive tape shall be carefully placed in contact with a portion of the coated surface and pressed firmly against that surface pulling the edge of the tape down over the edge of the mirror to ensure proper adhesion. The tape shall then be slowly removed, when the coating shall exhibit no signs of peeling off.

7.3 Radius of Curvature — The radius of curvature of a spherical mirror shall be within ±5 percent, unless otherwise specified.

7.4 Definition (Plane Mirror) — The finished mirror shall be tested for its definition by viewing the reflected image of a definition chart at the mirror surface. The image shall be well defined and free from distortion of any kind.

7.5 Temperature Test — The mirror shall be placed in a thermostatically controlled humidity cabinet at a temperature of 55 ± 2°C and a relative humidity of at least 95 percent for a continuous period of 24 hours. It shall then be removed from the humidity cabinet, cleaned, dried and tested for any signs of visible deterioration of the silvered film and its protective coating as well as for good definition.

7.6 Corrosion Test — The mirror shall be placed in a thermostatically controlled cabinet with a salt atmosphere for a continuous period of 24 hours at a temperature of 35 ± 2°C. The salt atmosphere shall be obtained by allowing a stream of air to bubble through a salt solution having the following composition:

Sodium chloride	27 g
Magnesium chloride, anhydrous	6·0 g
Calcium chloride, anhydrous	1·0 g
Potassium chloride	1·0 g
Distilled water	to make 1 000 ml

Care shall be taken that no condensate falls on the mirror. After the exposure period, the mirror may be cleaned by using tap water and dried. It shall not exhibit any visible signs of deterioration at the reflecting surface or its protective coating. It shall show good definition when tested by the method specified in **7.4**.

7.7 Figure — In the case of spherical or paraboloid mirrors, required for astronomical work, the figuring over each zone of the mirror shall be tested by the Foucault's Knife Edge Method which is also applicable to large telescope objectives.

7.8 Aluminized Mirrors (Front Coated Mirrors) — In the case of aluminized mirrors, further tests shall be applied in accordance with **7.8.1** to **7.8.3**.

7.8.1 *Hardness* — There shall be no noticeable deterioration of any kind on the mirror surface, including irremovable streaks or hairline scratches, when the mirror is rubbed against its surface in any direction 50 times with a pad of clean dry laundered cheese-cloth one centimetre in diameter and 1·25 cm in thickness and bearing with a load of 450 g.

7.8.2 *Cleanability*

7.8.2.1 Finished mirrors shall be capable of being cleaned by washing with laundered cheese-cloth saturated with soap and water, rinsed with tap water, and finally dried by vigorous rubbing by dry, clean linen or lens tissue.

7.8.2.2 A thick paste of precipitated chalk and water shall be applied to the mirror, allowed to dry and then wiped off with a soft clean cloth. There shall be no noticeable deterioration of the finished mirror surface after this operation.

7.8.3 *Liability to Stain* — A tiny drop of distilled water shall be permitted to dry at room temperature on the mirror surface. The surface shall then be cleaned with acetone (*see* IS : 170-1950*) or absolute alcohol (*see* IS : 321-1952*) and there shall be no stain left thereafter.

8. GRATICULES

8.0 Graticules used in optical instruments may be made either by mechanical ruling or by chemical etching after ruling on a resist; alternatively, they may be made by photographic methods, that is, by photo-printing or photo-etching or may be even produced by vacuum deposition over the pattern.

8.1 Surface — The surfaces of the graticule (blank) shall be plane parallel to within 30 seconds of arc except where the graticule pattern is formed on a curved surface.

8.1.1 The graticule pattern shall appear prominently against the background.

8.1.2 The edges of the lines of the pattern shall be sharp and well defined. The size of the breaks, if any, in lines of the pattern shall not exceed half the width of the corresponding line, and the number of such breaks shall not exceed three per graticule.

8.1.3 The width of the lines of the graticule pattern shall be within ±25 percent of the specified value, unless otherwise stated.

---

*Since revised.

8.1.4 The spacings between the lines of the graticules shall be correct to ±5 percent of the specified value, unless otherwise stated.

8.2 Durability Test — Except where the surface containing the graticule pattern is cemented to another glass plate or surface, the graticule surface shall be capable of withstanding normal cleaning by absolute alcohol (conforming to IS : 321-1952*) or Grade I methylated spirit and lens tissue of soft linen without the pattern being affected.

9. PLATES (PARALLEL AND PRISMATIC)

9.1 Parallelism (or Prismatic Error) — Lack of parallelism, if any, of the two faces of a parallel plate may be determined with an interferometer or by receiving the reflected images from the two faces of the plate and measuring the angular separation on the eyepiece scale of the autocollimator. The error, if present, shall not exceed ±30 seconds, unless otherwise stated.

9.2 Lensatic Error — The plate shall be free from lensatic error exceeding ±0·25 dioptre due to sphericity of the surfaces, determined as follows:

> Using a telescope and a collimator on the optical bench, initially adjust the telescope to receive the collimated beam such that the graticule of the collimator is perfectly in focus. Place the plate under test in front of the objective of the telescope. The collimator graticule should remain in perfect focus. In case it is not, due to lensatic error in the sample, the graticule should be brought back to focus with the help of dioptric lenses placed between the eye and the eyelens of the telescope eyepiece without disturbing the rest of the setting. The dioptre value of the neutralizing lens, but with the sign changed, represents the lensatic error of the plate under test.

9.3 Prismatic Plates

9.3.1 In the case of wedge-shaped or prismatic plates, the deviation angle shall be measured by any of the methods applicable to prisms and shall be within ±30 seconds of the nominal value, unless otherwise specified.

9.3.2 They shall also be tested for lensatic error by the method applicable to parallel plates and shall be within the same degree of accuracy, unless otherwise specified.

10. OPTICAL FILTERS

10.0 Optical filters may be of a single coloured glass (or plastic) plate or a coloured gelatine film sandwiched between two transparent glass or plastic plates or formed by deposition on glass of a multilayer film of appropriate materials under high vacuum conditions.

---

*Since revised.

10.1 Thickness — In the case of glass or gelatine based filters, the filter material shall be of highest quality and of uniform composition and the actual thickness of the filter material shall not vary by more than ±0·1 mm from the specified value.

10.2 Parallelism — The departure from parallelism between the two surfaces of a glass or plastic filter or of the base of a gelatine filter shall not normally exceed one minute of arc, unless otherwise specified.

10.3 In the case of all filters, the transmission coefficient of the filters, when measured by the spectro-photometric method shall be within ±5 percent of the specified value and the spectral distribution of the transmitted radiation through the filter shall reasonably correspond to the specified distribution curve with the maximum transmission lying within ±50 Å of the stipulated wavelength.

11. MARKING

11.1 The magnification and the numerical aperture of a microscope objective shall be indelibly marked on the lens mount.

11.2 In the case of a camera lens, the focal length in millimetres and the *F* number shall be marked on the lens mount.

NOTE — For more specific requirements and tests applicable to special types of lenses like Telescope Objectives, Microscope Objectives, Camera Lenses and Projection Lenses, reference should be made to the appropriate specifications.

11.3 Where possible, the ground edge or surface or the painted surface of the optical component shall be indelibly marked with the manufacturer's initial and identification number together with the year of manufacture, where so desired by the purchaser; otherwise the markings may be indicated on the outside of the packing. In no case, shall the markings be given on the active surface of the component.

12. PACKING AND PACKAGING

12.1 Optical components shall be so securely packed for storage and transit that there is no liability, whatsoever, for any deterioration or damage taking place.

12.1.1 The components in their clean condition, free from dirt, grit or other extraneous material, shall be initially wrapped in acid free tissue paper and put individually or in small batches in suitable compartments of a thick cardboard carton and further packed inside the carton with paper wool, cotton waste or cotton and corrugated cardboard together with a small linen bag containing reconditioned silica gel.

12.1.2 Optical components, with or without the tissue paper covering, may also be sealed in suitable polythene bags before packing in the cardboard cartons. Cardboard cartons so packed shall be further wrapped in kraft paper, laminated metal foil or other suitable moisture-resistant covering which shall be subsequently sealed by wax dipping or heat sealing, as the case may be.

12.1.3 The requisite number of cardboard cartons so packed shall be placed in a wooden case lined with waterproof paper with plenty of cushioning material all round and securely packed for transit.

12.2 The package shall, on top, give the description and number of contents inside and shall be marked with the standard symbol for fragility (*see* IS : 1286 - 1958*) together with the legend ' Handle with Care ' in red and also the symbol for ' Right Way Up ' (*see* IS : 1286 - 1958*).

APPENDIX A

(*Clause* 4.6)

TEST FOR THE HARDNESS OF BLOOMING ON THE SURFACES OF OPTICAL COMPONENTS

A-1. The ability of bloomed film (anti-reflecting films on glass surfaces) to resist surface scratching as well as its adherence to the glass base may be tested with the help of the machine illustrated in Fig. 1. The principle made use of in the machine is to effect relative motion between the bloomed surface and an abrader which is a typewriter eraser of the best quality. The touching surface of the abrader is suitably radiused to provide a very small area of contact. The test specimen is a sample plate of glass 5 × 5 cm surface area and 2 to 4 mm thick, which is bloomed at the same time as the optical component under test. The test specimen is given a reciprocating motion on the machine with the abrader or stylus in contact under a fixed load of, say, 200 g. The surface is visually examined after a given number of strokes, say, 25.

A-2. The following chart gives the grading of the film with respect to its surface quality for a load of 200 g and 25 to and fro strokes:

Grade	*Surface Quality*
0	Unaffected
1	Slightly scratched
2	Moderately scratched
3	Heavily scratched
4	Clear streaks
5	Film completely removed

---

*Since revised.

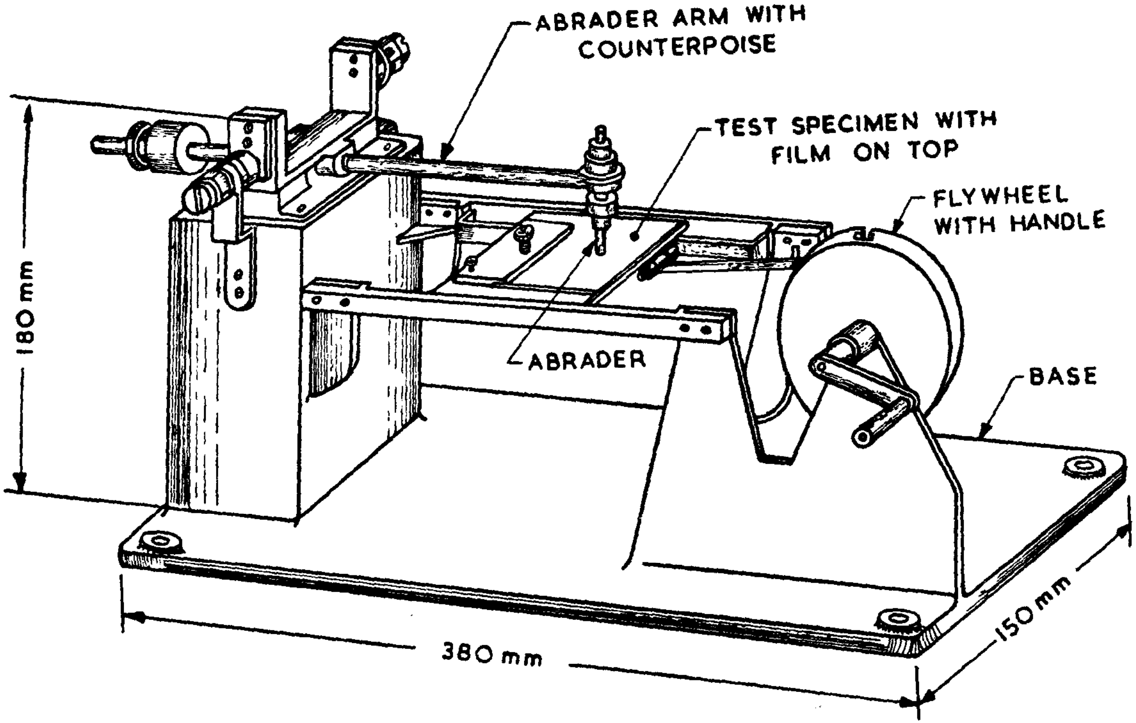

Fig. 1 Machine for Testing the Hardness of Bloomed Surfaces

APPENDIX B

(*Clauses* 0.4.1 *and* 5.1)

PREFERRED RADII OF CURVATURE OF GLASS-WORKING TOOLS

B-1. Preferred radii of curvature in millimetres of glass-working tools for spherical surfaces as recommended for adoption in optical design and industry are given in Table I.

B-1.1 In Table I the leading digits of the serial number *n* of the tool are placed in the first column, and subsequent digits at the heads of the remaining columns, the quantity given by the table for any particular value of *n* occurring where the row containing the leading digits crosses the column with the concluding figures. Thus from the table, the radius corresponding to $n = 243$ is 46·96 mm.

APPENDIX C

(*Clause* 5.2.1)

METHODS FOR THE DETERMINATION OF THE EQUIVALENT FOCAL LENGTH OF A LENS OR LENS COMBINATION

C-1. NODAL POINT METHOD

C-1.1 The lens or lens combination is mounted on the optical bench on a support that can rotate about a vertical axis that passes through the axis of the lens at right angles. The image of a distant object or of the illuminated graticule of a collimator, also mounted on the optical bench, is formed by the lens on a ground glass screen or is viewed by means of a microscope mounted on the bench on the other side of the lens under test. The positions of the lens and the screen (or microscope) are adjusted in such a manner that, when the lens is slightly rotated in its support, either way, about the vertical axis, there is no shift, in the image observed. In this position, the vertical axis of rotation of the lens (or lens combination) intersects the axis of the lens at its back nodal point, and the distance between this point and the position of the image gives the equivalent focal length of the lens (or lens combination).

C-2. NEWTON'S METHOD

C-2.1 According to Newton's formula, the product of the distance of an object from the first focal point of a lens or lens system and the distance of the image from its second focal point is equal to the square of the (equivalent) focal length of the lens (*see* Fig. 2). To make use of this relationship to determine the focal length, mount the lens (or lens combination)

TABLE I PREFERRED RADII OF CURVATURE OF GLASS-WORKING TOOLS

(*Clauses* B-1 *and* B-1.1)

	0	1	2	3	4	5	6	7	8	9
0	∞	21 600	10 800	7 160	5 350	4 270	3 550	3 030	2 460	2 340
1	2 099	1 902	1 738	1 599	1 480	1 377	1 287	1 207	1 136	1 073
2	1 016	965	918	875	836	800	767	736	708	681
3	656·6	633·5	611·8	591·5	572·3	554·3	537·3	521·2	505·9	491·5
4	477·8	464·7	452·3	440·5	429·2	418·4	408·1	398·3	388·9	379·8
5	371·1	362·8	354·8	347·1	339·7	332·6	325·7	319·1	312·7	306·5
6	300·5	294·8	289·2	283·8	278·6	273·6	268·6	263·9	259·3	254·8
7	250·5	246·3	242·1	238·2	234·3	230·6	226·9	223·4	219·9	216·5
8	213·2	210·0	206·9	203·9	200·9	198·0	195·2	192·4	189·7	187·1
9	184·5	182·0	179·5	177·1	174·8	172·5	170·2	168·0	165·9	163·8
10	161·72	159·70	157·72	155·78	153·88	152·02	150·19	148·40	146·65	144·92
11	143·24	141·58	139·95	138·36	136·79	135·25	133·74	132·26	130·81	129·38
12	127·97	126·59	125·23	123·90	122·59	121·30	120·03	118·79	117·56	116·36
13	115·17	114·01	112·86	111·73	110·62	109·52	108·45	107·39	106·34	105·31
14	104·30	103·30	102·32	101·35	100·40	99·46	98·54	97·62	96·73	95·84
15	94·97	94·10	93·26	92·42	91·59	90·78	89·98	89·18	88·40	87·63
16	86·87	86·12	85·38	84·65	83·93	83·22	82·52	81·83	81·14	80·47
17	79·80	79·14	78·49	77·85	77·21	76·59	75·97	75·36	74·76	74·16
18	73·57	72·99	72·41	71·84	71·28	70·73	70·18	69·64	69·10	68·57
19	68·05	67·53	67·02	66·51	66·01	65·52	65·03	64·55	64·07	63·59
20	63·13	62·66	62·21	61·75	61·30	60·86	60·42	59·99	59·56	59·13
21	58·71	58·30	57·89	57·48	57·08	56·68	56·28	55·89	55·50	55·12
22	54·74	54·37	53·99	53·63	53·26	52·90	52·54	52·19	51·84	51·49
23	51·15	50·81	50·47	50·14	49·80	49·48	49·15	48·83	48·51	48·20
24	47·88	47·57	47·27	46·96	46·66	46·36	46·07	45·77	45·48	45·19
25	44·91	44·63	44·35	44·07	43·79	43·52	43·25	42·98	42·71	42·45
26	42·19	41·93	41·67	41·42	41·16	40·91	40·67	40·42	40·18	39·93
27	39·69	39·45	39·22	38·98	38·75	38·52	38·29	38·07	37·84	37·62
28	37·40	37·18	36·96	36·74	36·53	36·32	36·11	35·90	35·69	35·48
29	35·28	35·08	34·88	34·68	34·48	34·28	34·09	33·89	33·70	33·51

(*Continued*)

TABLE I PREFERRED RADII OF CURVATURE OF GLASS-WORKING TOOLS — *Contd*

	0	1	2	3	4	5	6	7	8	9
30	33·321	33·134	32·947	32·762	32·579	32·397	32·216	32·037	31·858	31·682
31	31·506	31·332	31·159	30·987	30·817	30·648	30·480	30·313	30·147	29·983
32	29·820	29·658	29·497	29·337	29·179	29·021	28·865	28·710	28·555	28·402
33	28·250	28·099	27·949	27·800	27·652	27·506	27·360	27·215	27·071	26·928
34	26·786	26·645	26·505	26·366	26·228	26·091	25·955	25·819	25·685	25·501
35	25·418	25·286	25·155	25·025	24·896	24·768	24·640	24·513	24·387	24·262
36	24·138	24·014	23·892	23·770	23·649	23·528	23·409	23·290	23·172	23·054
37	22·938	22·822	22·707	22·592	22·478	22·365	22·253	22·142	22·031	21·920
38	21·811	21·702	21·594	21·486	21·379	21·273	21·167	21·062	20·958	20·854
39	20·751	20·649	20·547	20·445	20·345	20·245	20·145	20·046	19·948	19·850
40	197·53	19·657	19·561	19·465	19·370	19·276	19·182	19·089	18·996	18·904
41	18·812	18·721	18·631	18·540	18·451	18·362	18·273	18·185	18·098	18·011
42	17·924	17·838	17·752	17·667	17·583	17·498	17·451	17·331	17·249	17·166
43	17·084	17·003	16·922	16·842	16·761	16·682	16·603	16·524	16·445	16·368
44	16·290	16·213	16·136	16·060	15·984	15·909	15·834	15·759	15·685	15·611
45	15·537	15·464	15·392	15·319	15·247	15·176	15·105	15·034	14·964	14·893
46	14·824	14·754	14·685	14·617	14·549	14·481	14·413	14·346	14·279	14·212
47	14·146	14·080	14·015	13·950	13·885	13·820	13·756	13·692	13·629	13·565
48	13·503	13·440	13·378	13·316	13·254	13·193	13·132	13·071	13·010	12·950
49	12·890	12·831	12·772	12·713	12·654	12·595	12·537	12·479	12·422	12·365
50	12·308	12·251	12·194	12·138	12·082	12·027	11·971	11·916	11·861	11·807
51	11·752	11·698	11·644	11·591	11·538	11·485	11·432	11·379	11·327	11·275
52	11·223	11·171	11·120	11·069	11·018	10·967	10·917	10·867	10·817	10·767
53	10·718	10·669	10·620	10·571	10·522	10·474	10·426	10·378	10·330	10·283
54	10·235	10·188	10·141	10·095	10·048	10·002	9·956	9·910	9·865	9·819
55	9·774	9·729	9·685	9·640	9·596	9·551	9·507	9·464	9·420	9·377
56	9·333	9·290	9·247	9·205	9·162	9·120	9·078	9·036	8·994	8·953
57	8·911	8·870	8·829	8·788	8·748	8·707	8·667	8·627	8·587	8·547
58	8·507	8·468	8·428	8·389	8·350	8·312	8·273	8·234	8·196	8·158
59	8·120	8·082	8·045	8·007	7·970	7·932	7·895	7·858	7·822	7·785

60	7·749	7·712	7·676	7·640	7·604	7·569	7·533	7·498	7·463	7·427
61	7·392	7·358	7·323	7·288	7·254	7·220	7·186	7·152	7·118	7·084
62	7·050	7·017	6·984	6·950	6·917	6·885	6·852	6·819	6·787	6·754
63	6·722	6·690	6·658	6·626	6·594	6·563	6·531	6·500	6·468	6·437
64	6·406	6·375	6·345	6·314	6·283	6·253	6·223	6·192	6·162	6·132
65	6·103	6·073	6·043	6·014	5·984	5·955	5·926	5·897	5·868	5·839
66	5·811	5·782	5·753	5·725	5·697	5·669	5·641	5·613	5·585	5·557
67	5·529	5·502	5·474	5·447	5·420	5·393	5·366	5·339	5·312	5·285
68	5·259	5·232	5·206	5·179	5·153	5·127	5·101	5·075	5·049	5·024
69	4·998	4·972	4·947	4·922	4·896	4·871	4·846	4·821	4·796	4·771

	00	10	20	30	40	50	60	70	80	90
7	4·747	4·504	4·270	4·044	3·826	3·616	3·412	3·216	3·026	2·870
8	2·664	2·491	2·324	0·163	2·006	1·854	1·707	1·564	1·425	1·291
9	1·160	1·034	0·911	0·791	0·675	0·562	0·452	0·345	0·241	0·140
10	0·042	—	—	—	—	—	—	—	—	—

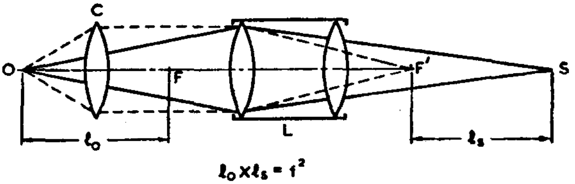

FIG. 2 ILLUSTRATION OF NEWTON'S METHOD

(for determining the focal length of a lens or lens combination)

L on an optical bench at some distance from an illuminated object *O* (cross line diaphragm). Temporarily introduce a short focus positive lens *C* between the object and the lens to get a collimated beam and obtain the position of the second focal point *F′* of the lens by focusing the image of the object on a ground glass screen. Similarly, by reversing the lens in its position, determine the position of the first focal point *F*. Having thus determined the positions (or distances) of *F* and *F′* with respect to the nearest surface of the lens, remove the auxiliary lens *C* and focus the image of *O* on the screen *S*. The square root of the product of the two distances, *OF* and *F′S* gives the equivalent focal length of the lens or lens combination.

C-3. MAGNIFICATION METHOD

C-3.1 For a fixed position of the lens, the size and location of the image of an illuminated circular aperture or millimetre scale on glass are obtained for two positions of the object. If d is the size of the object and D_1 and D_2 are the sizes of the image, as measured by a micrometer eyepiece, corresponding to the distances V_1 and V_2 of the image from the lens, the equivalent focal length (f) of the lens (or lens system) is given by the formula:

$$f = \frac{(V_2 - V_1)\, d}{D_2 - D_1}$$

BUREAU OF INDIAN STANDARDS

Headquarters;
Manak Bhavan, 9 Bahadur Shah Zafar Marg. NEW DELHI 110002
Telephones : 331 01 31, 331 13 75
Telegrams : Manaksanstha
(Common to all offices)

Regional Offices:		*Telephones*
Central	: Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI-110002	331 01 31 331 13 75
*Eastern	: 1/14 C.I.T. Scheme VII M, V. I. P. Road, Maniktola, CALCUTTA 700054	36 24 99
Northern	: SCO 445-446, Sector 35-C, CHANDIGARH 160036	2 18 43 3 16 41
Southern	: C. I. T. Campus, MADRAS 600113	41 24 42 41 25 19 41 29 16
†Western	: Manakalaya, E9 MIDC, Marol, Andheri (East), BOMBAY 400093	6 32 92 95

Branch Offices:	
'Pushpak' Nurmohamed Shaikh Marg, Khanpur, AHMEDABAD 380001	2 63 48 2 63 49
‡Peenya Industrial Area, 1st Stage, Bangalore Tumkur Road BANGALORE 560058	38 49 55 38 49 56
Gangotri Complex, 5th Floor, Bhadbhada Road, T. T. Nagar, BHOPAL 462003	6 67 16
Plot No. 82/83, Lewis Road, BHUBANESHWAR 751002	5 36 27
53/5, Ward No. 29, R. G. Barua Road, 5th Byelane, GUWAHATI 781003	3 31 77
5-8-56C L. N. Gupta Marg (Nampally Station Road), HYDERABAD 500001	23 10 83
R14 Yudhister Marg, C Scheme, JAIPUR 302005	6 34 71 6 98 32
117/418 B Sarvodaya Nagar, KANPUR 208005	21 68 76 21 82 92
Patliputra Industrial Estate, PATNA 800013	6 23 05
T.C. No. 14/1421, University P.O., Palayam TRIVANDRUM 695035	6 21 04 6 21 17
Inspection Office (With Sale Point) :	
Pushpanjali, 1st Floor, 205-A West High Court Road, Shankar Nagar Square, NAGPUR 440010	2 51 71
Institution of Engineers (India) Building, 1332 Shivaji Nagar, PUNE 411005	5 24 35

---

*Sales Office in Calcutta is at 5 Chowringhee Approach, P.O. Princep Street, Calcutta 700072 27 68 00

†Sales Office in Bombay is at Novelty Chambers, Grant Road, Bombay 400007 89 65 28

‡Sales Office in Bangalore is at Unity Building, Narasimharaja Square Bangalore 560002 22 36 71

Printed at Simco Printing Press, Delhi, India